



China

HollySys Group (Group Headquarters)
No.2 Di Sheng Middle Road, Economic-Technological Development Area, Beijing 100176
Tel: +86 10 58981000 Fax: +86 10 58981100
Hangzhou HollySys Automation Co., Ltd. (Industrial Automation Headquarters)
No.1 North No.19 Street, Qiantang District, Hangzhou 310018
Tel: +86 571 81633600 Fax: +86 571 81633700

Singapore

HollySys (Asia Pacific) Pte. Ltd. (International Headquarters)
Changi Business Park Crescent, #04-01/02/03 Plaza 8 @ CBP, Tower A, Singapore 486025
Tel: +65 6777 0950 Fax: +65 6777 2730

India

HollySys Automation India Pvt. Ltd.
D-84, Ground Floor, Sector 63, Noida, Uttar Pradesh 201301
Tel: +91 12045 50652

Indonesia

PT. HollySys Automation Indonesia
Metropolitan Tower, 10th Floor Unit E, Jl. R.A. Kartini Kav. 14, Jakarta 12430
Tel: +62 21 2918 2926 Fax: +62 21 2918 2936

Web: www.hollysys.com
E-mail: sales_international@hollysys.com (Sales)
iaservice@hollysys.com (After-sales Service)



**STEAM TURBINE CONTROL
SYSTEM PRODUCT
INTRODUCTION**

**Intelligence
For Excellence**

Profile

Founded in 1993, HollySys is a leading supplier of intelligence solutions with more than 4,700 employees and operates in both China and abroad. HollySys is headquartered in Beijing with R&D, production, and service bases in Beijing, Hangzhou, Xi'an, Singapore, and local branches in major cities in China, as well as offices in India, Malaysia and Indonesia, establishing a comprehensive service network across the world.

HollySys business consists of industrial intelligence, transportation intelligence, and food and pharmaceutical intelligence, covering the main industries for the national economy and the people's livelihood. With years of technological accumulation in various fields and continuous capacity building, we can provide customers with customized integrated solutions, stable and reliable products, and full lifecycle services, helping them improve market competitiveness. Over the past three decades, we have served more than 35,000 clients, successfully completed more than 45,000 projects, and gained more than 1,000 new clients each year, making HollySys a world-renowned brand in automation and intelligence filed.

The HOLLIAS industrial control platform of HollySys features a series of advanced, practical and reliable industrial automation systems and HollySys automation instrumentations products. The system products include MACS-K, MACS-S industrial control system DCS, professional control systems such as DEH, ETS and SIS, and whole-process information-based software for manufacturing enterprises. Instrumentation products include isolated safety barriers, signal isolators, surge protectors, power transmitters, pressure transmitters, electromagnetic flowmeters, metal tube float meters, magnetic level gauges, radar level gauges, throttling elements, thermal elements, and pressure gauges.

The company's products have been successfully applied to major projects and key equipment, including 1000MW ultra-supercritical thermal power units, 1.2 million tons of urea and 5 million tons of oil refining main units, earning a good reputation in the industry.

Specializing in HollySys Instrumentation and control system engineering and integration, the company can provide both new and brown field projects of enterprises with HollySys proprietary products, as well as comprehensive engineering services such as customized design and construction & commissioning.

HollySys has always pursued continuous innovation and R&D while sticking to its vision "create the most valuable intelligent company through stable and sustainable development" to provide more reliable, secure, and intelligent technology and products for our customers.

Contents

DEH: Digital Electro-Hydraulic (DEH) Turbine Control System	1
HollySys Turbine Control Products	2
HollySys Turbine Control System	4
Hydraulic Servo System	15
HollySys Isolated Grid Coordinated System	20
DEH Install Base	22

DEH: Digital Electro-Hydraulic (DEH) Turbine Control System

Since the successful development and application of HollySys DEH in 1997 under the guidance of prestigious experts in China's turbine control field, digital electro-hydraulic turbine control systems applicable to 1,000 MW, 600 MW, 300 MW, 200 MW and small and medium-sized units have been developed.

- In 1997, the first generation DEH system, i.e. 200 MW unit electro-hydraulic DEH, was launched and put into operation in Jilin Changshan Power Plant successfully.
- In 1998, the 200 MW unit high-pressure fire resistant oil DEH was developed and put into operation in Guizhou Qingzhen Power Plant successfully.
- In 1999, 5 types of DEH systems were put into operation successively and obtained the first DEH related patent certificate, making DDV valve technology applied to DEH system successfully.
- From 2000 to 2004, nine DEH related patent certificates were obtained, and 300 MW high-pressure fire-resistant oil DEH was developed successfully.
- In 2005, the DEH system running in isolated grid was developed, and applied to many power plants such as Huo Meihong Jun Aluminum Power Company and Shandong Weiqiao Pioneering Group., Ltd. successfully.
- In 2006, the self-contained DEH system was developed and put into operation on each unit successfully.
- In 2007, the drive turbine DEH system was developed and put into operation in steel and petrochemical industries successfully.
- In 2008, the turbine control module was developed and widely applied in small units.
- In 2010, HollySys DEH was applied to 600 MW supercritical units in Guohua Hulunbuir Power Plant successfully.
- In 2012, the 1000 MW ultra-supercritical extraction condensing heating unit of Fujian Shishi Hongshan Thermal Power Plant was applied successfully.
- In 2013, redundant servo modules were developed and applied successfully.
- In 2016, a fast master control system was developed successfully to meet the high-speed requirements of ultra-supercritical units.
- In 2017, the first new MW unit - Guohua Ningdong 2X660 MW ultra-supercritical unit of Harbin Turbine Co., Ltd. was applied successfully.
- Up to now, more than 4,000 sets of HollySys DEHs have been applied to new and renovated turbine units of various models ranging from 3 MW to 1,000 MW successfully, with 25 patent applications.

HollySys Turbine Control Products

DEH Electronic Control System Products

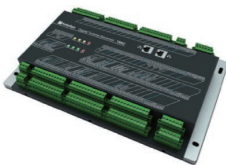
T800K Digital Electro-hydraulic Turbine Control System

The T800K is a Digital Electro-Hydraulic (DEH) Turbine Control System for steam turbines. It is based on the HOLLIAS MACS-.K platform. With full-digital intelligent servo and speed measurement protection modules, T800 can develop various more advanced control functions for turbines according to different user requirements, and can be configured with a full range of I/O redundant modules with higher reliability and safety.



T80/T80C Single/dual-channel Universal Turbine Control Module

The T80/T80C single/dual-channel universal turbine control module is a small turbomachinery control device, which is applicable to various units such as waste heat power generation unit, waste power generation unit, biomass power generation unit, solar thermal power generation unit and industrial drive unit. It can provide control strategies such as isolated grid operation, thermoelectric regulation, steam makeup regulation and sliding pressure operation. The controller hardware is an industrial-grade component which conforms to military standard GJB/Z35-93, and its anti-electromagnetic interference ability conforms to GJB151A, HJB34-1990 and IEC61000-4, so that the controller can operate stably and reliably for a long term in industrial environment.



Turbine Safety Protection Products

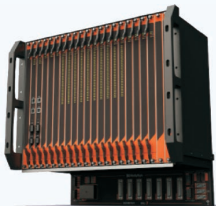
ETS-LM Turbine Emergency Trip System

The ETS-LM turbine emergency trip system is a safe and reliable protection device equipped for the turbine unit, which can trip the turbine automatically and ensure its safety in case of any danger that may cause damage to the turbine. ETS-LM adopts dual CPU and I/O, which improves reliability and flexibility of the protection system significantly.



HiaGuard Turbine Safety Class Protection Device

The HiaGuard system is a safety instrumented system developed by HollySys Group for the field of industrial automation safety. It is the first safety instrumented system with intellectual property rights in China, and has been certified by TÜV (Rheinland Industrie Service GmbH). HiaGuard is a programmable electronic system (PES) as defined in IEC 61508, which reaches SC3 (system capability level) and SIL3 (hardware safety integrity level) as defined in IEC 61508 (2010), and its target applications are safety-related applications in low operating modes reaching SIL3 and below as defined in IEC 61508 (2010). The safety class protection device is a triple redundant system, which adopts the 2oo3D architecture with diagnosis to realize emergency shutdown function.



DEH Hydraulic Servo Systems

EH-ZRS Self-contained Electro-hydraulic Actuator

The self-contained DEH hydraulic system consists of independent oil source station, electro-hydraulic actuator group and emergency trip system. It is an electro-hydraulic actuator with its own oil source. The internal working medium is anti-wear hydraulic oil. The system using anti-wear oil as working medium is called self-contained anti-wear oil electro-hydraulic control system. The self-contained electro-hydraulic servo system is designed with independent oil source, high positioning accuracy, great driving force, and stepless speed regulation and quick closing protection functions. It is a highly cost effective product which is mainly applied to the hydraulic servo-motor system of turbomachinery control valve.



EH-HP Fire-resistant Oil System

The high-pressure fire-resistant oil system is mainly composed of oil supply system, actuator and emergency trip system. The oil supply system is an EH oil storage and treatment center, which provides stable high-pressure oil to the EH system to drive the actuator. The actuator responds to the electric control command signal from DEH, so as to adjust the opening of each steam valve of the turbine. The emergency trip system is controlled by trip parameters of the turbine, which will close all steam inlet valves or only close the control valve when these parameters exceed the limit value, so as to ensure normal and safe operation of the turbine.



EH-LP Turbine Oil System

The electro-hydraulic servo valve is used as the electro-hydraulic conversion device. The design philosophy of integrated oil way achieves a standard and integrated control system. The hydraulic spring type servo-motor is designed, which is not affected by changes in system oil pressure, and has a high control sensitivity and fast response. The low-pressure turbine oil system has been widely applied to various small and medium-sized units.

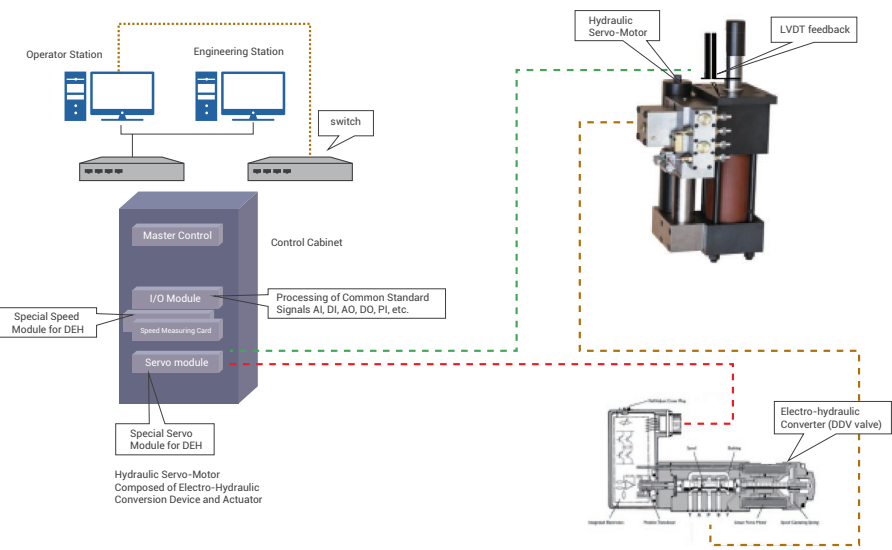


HollySys Turbine Control System

T800K Control System

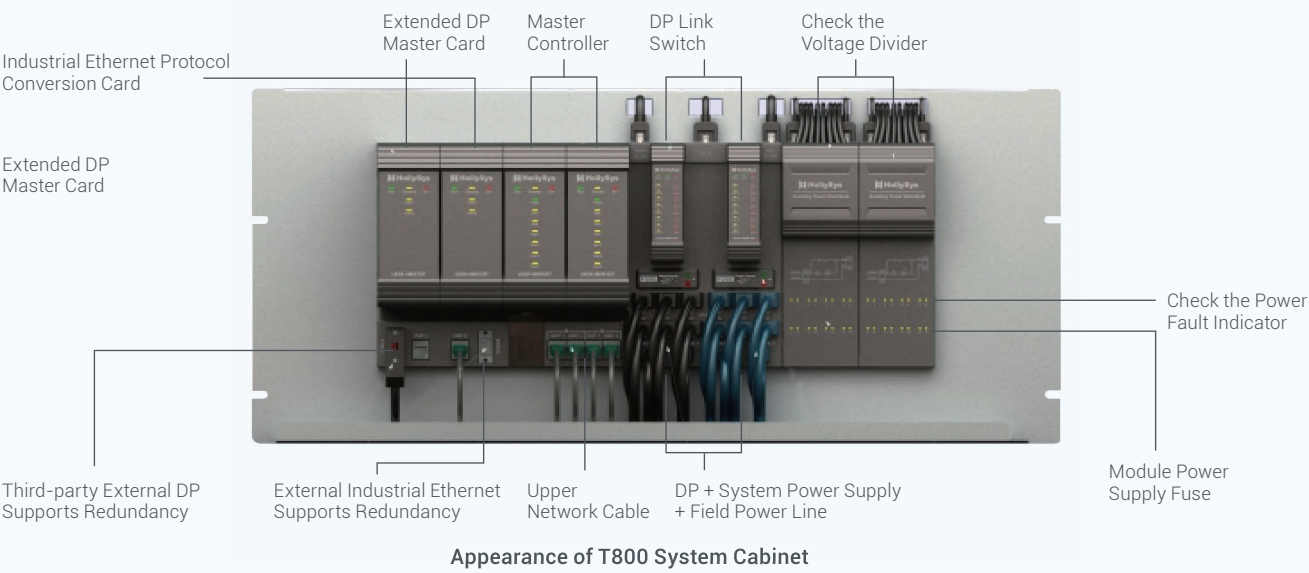
Overview

The T800K digital electro-hydraulic turbine control system is a turbine DEH system designed based on K series hardware in the HOLLIAS® MACS system. With the strong ability to extend and monitor the main engine and auxiliary system of the turbine, T800 can develop various more advanced control functions for the turbine according to different user requirements.



Characteristics of T800K

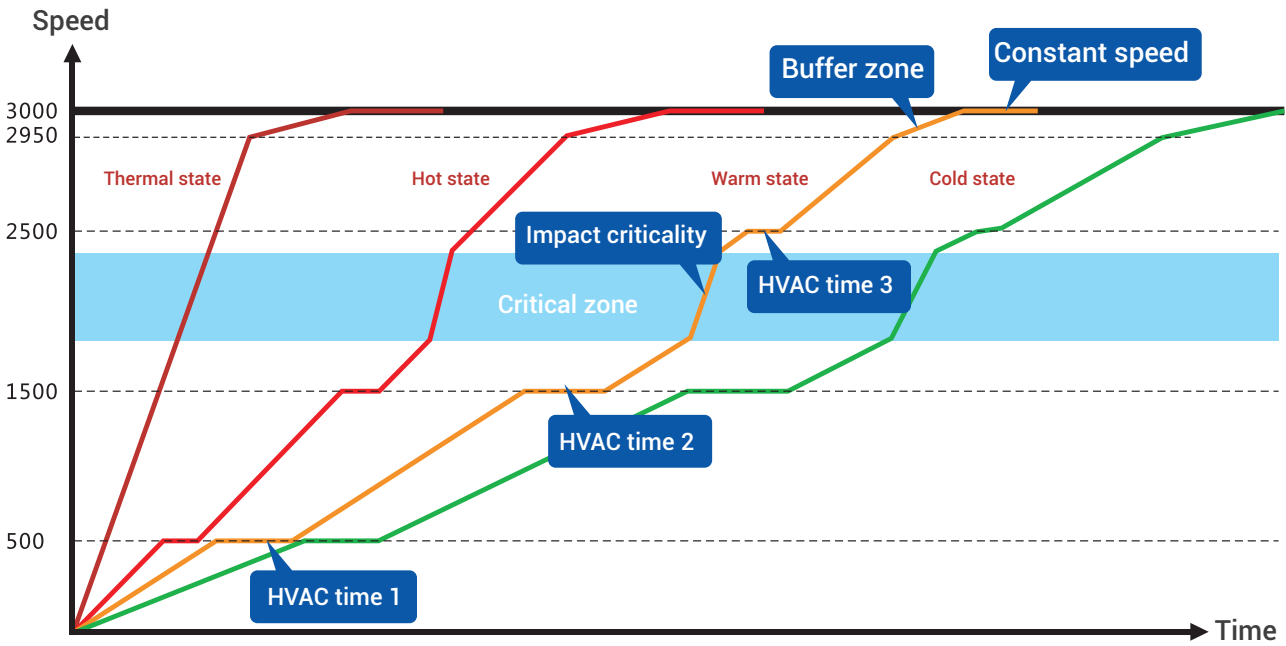
- Fully redundant multi-functional bus realizes full redundancy of system power supply, field power supply and communication bus
- A full range of module redundancy including RTD, TC, AI, AO, DI and DO can be configured
- It supports execution cycles of 50 ms, 100 ms, 200 ms, 500 ms, 1000 ms and 2000 ms, which can be set separately for each scheme page, so as to be suitable for different sites
- The module can adapt to both bus and star topological structures, with full redundancy from transceiver to communication cable
- The system supports DP communication rate of 1.5 Mbps-3 Mbps, facilitating access to third-party DP equipment. The system supports access to 100 Mbps industrial Ethernet equipment and FF-HSE equipment
- It also supports connecting modules to other systems via Ethernet. The symbol of the whole series of products conforms to the ISA-S71.04-1985 G3 protection standard. It can adapt to the high humidity, temperature of 20-60° C, and sites up to 3000m above sea level
- It has been certified by FM, UL and CE
- Intelligent DEH special module: K-FC01 speed module and K-SV01 servo module
 - 1) Fully digital programmable modules, with digital settings for the number of teeth, tripping speed, acceleration thresholds and servo proportional-integral, etc
 - 2) It can be used as not only a stand-alone but also an integrated component of the HollySys master control system via PROFIBUS-DP bus
 - 3) Electro-hydraulic servo control output in the range ± 10 V and ± 200 mA to drive various electro-hydraulic servo valves
 - 4) 6-wire or 3-wire LVDT, which accesses the servo control module directly for modulation and demodulation
 - 5) Control cycle <5 ms, ensuring DEH regulation quality and isolated grid operation capability
 - 6) Communication with other control systems via MODBUS
 - 7) Connection to fast LAN via CAN bus
- The control system is designed according to the principles of "fail-safe" and "secure self-locking"
- The K-FC01 speed measurement template adopts a 2oo3 redundant configuration mode
- I/O module, main control unit and power supply are all capable of live plugging
- All I/O modules are of intelligent design



T800K Function

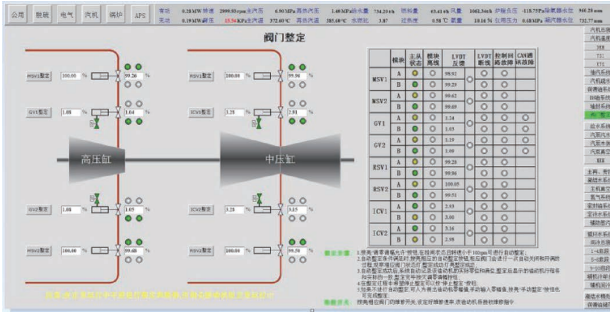
Functions of control system

Accelerate control.
The unit can be controlled according to its thermal state to automatically complete impulse starting, automatic speed accelerate, warming up and passing through the critical speed area based on the empirical curve program until the constant speed reaches 3000 r/min.



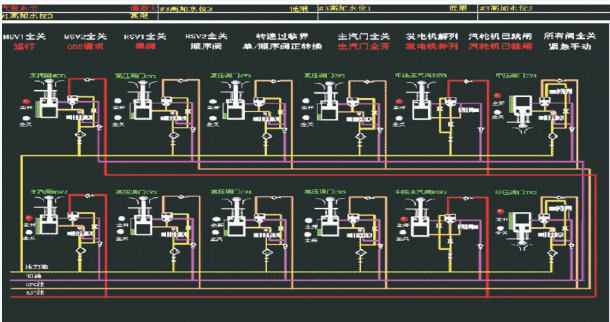
Limit control functions

- Overspeed limit
- Valve position limit
- High load limit
- Low limit for main steam pressure
- Quick release load
- Low vacuum load limit



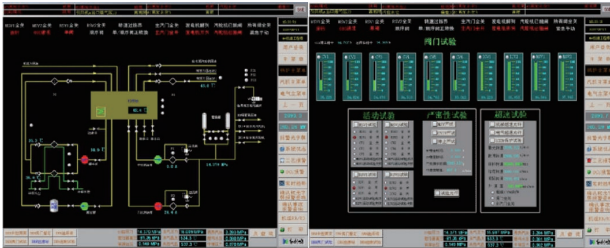
Protection control functions

- Overspeed protection
- Original mechanical overspeed protection
- Original TSI electrical overspeed protection
- DEH software configuration overspeed protection
- Hardware overspeed protection of DEH speed measuring board



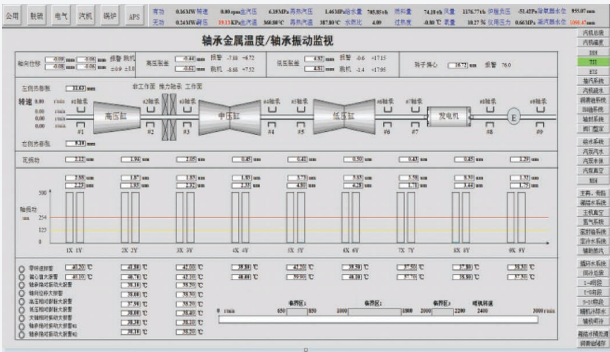
System testing functions

- False grid connection test
- Overspeed test
- Valve movement test
- Valve tightness test
- High-voltage trip module test
- OPC quick-closing regulating valve test
- Fuel injection test
- Off-line simulation test

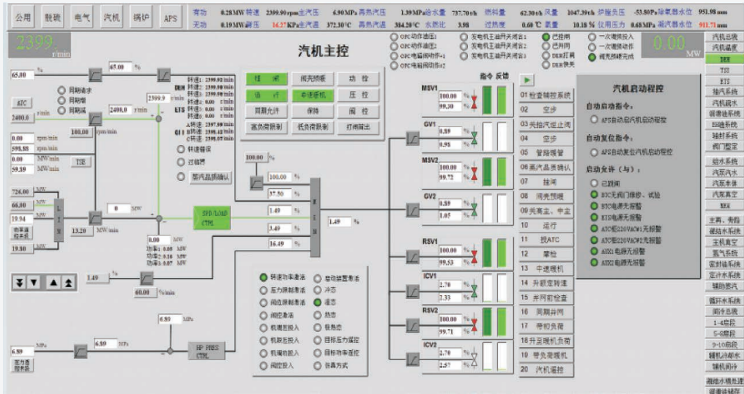


Special functions

- Automatic judgment of thermal status
- Two startup modes (with intermediate reheating units)
- Valve management (in case of one valve for one machine)
- Automatic startup of turbine - ATC (for large units)
- Operation record, equipment status display, data display and alarm printing, historical data query

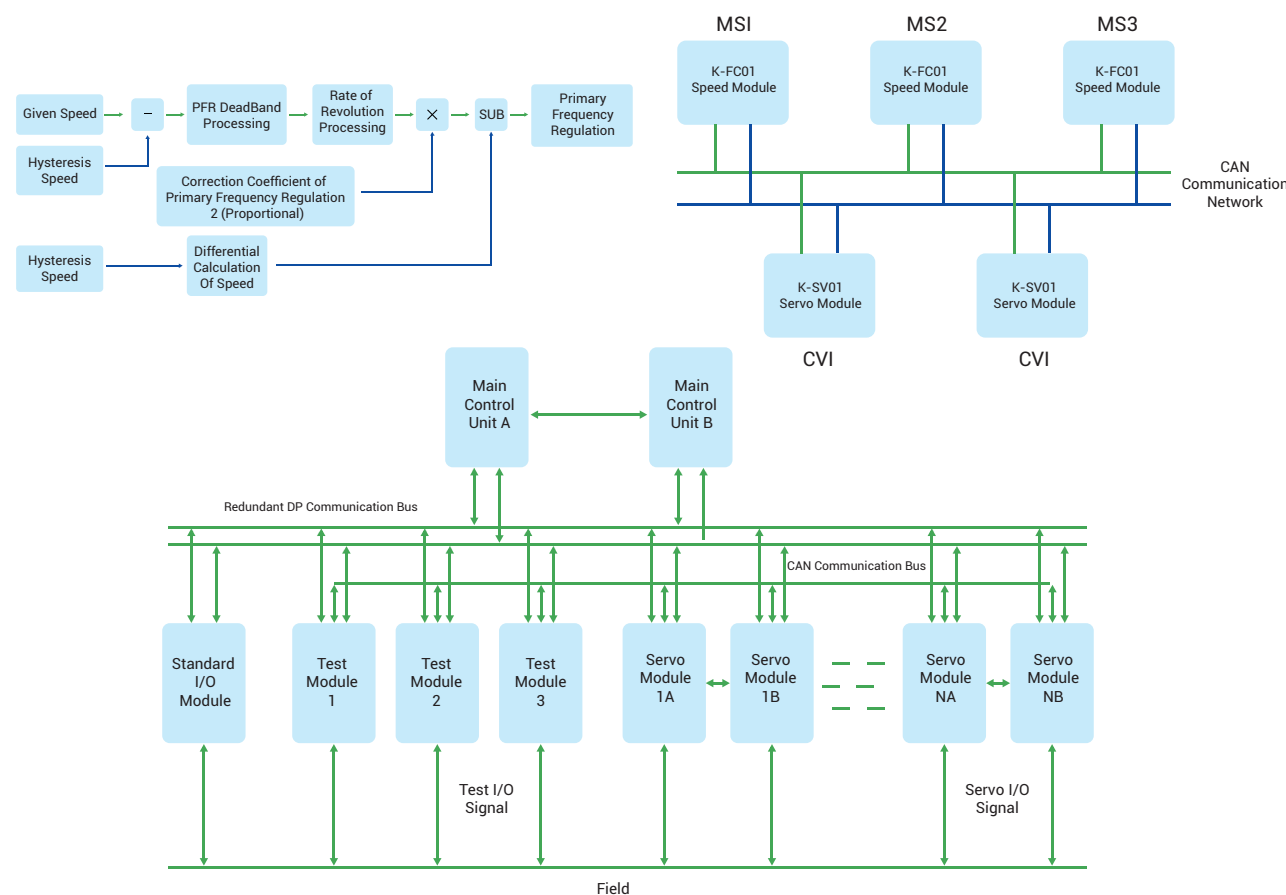


- Synchronous grid connection
- Valve control mode
- Power control mode
- Voltage control mode
- CCS mode
- Primary frequency regulation
- Emergency manual operation



Primary frequency regulation function

The speed module calculates the deviation between given speed and hysteresis speed, corrects it through PFR dead band processing, unequal rate processing and PFR correction coefficient, and then subtracts derivative feedback of the speed to generate PFR. The PFR is transmitted to the servo module via CAN communication link for quick regulation, and uploaded to the main control unit via DP.



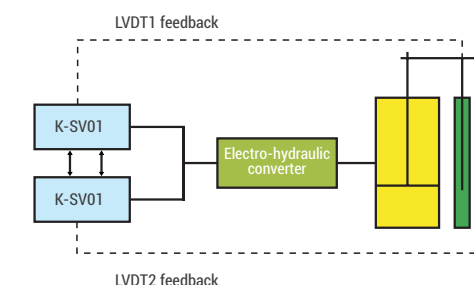
T800K Performance Index

- Speed control range: 40-3600 r/min
- Speed control accuracy: $\leq \pm 1$ r/min
- Rate of revolution: continuously adjustable within 3-6%
- Load control accuracy: +0.5%
- Extraction pressure control accuracy: ± 0.01 MPa
- Control system insensitivity: <0.06%
- Control system control cycle: <50 ms
- Maximum speed during load shedding: <7%
- Mean continuous runtime (MTBF): $\geq 25,000$ hours
- System availability: $\geq 99.9\%$
- Anti-interference measures are taken for the system to resist the interference from various electromagnetic waves and communication equipment on site

DEH Redundant Servo System Products

Functions and Specifications of Redundant Servo Channel

- Any servo channel in DEH can realize online redundant hot standby, and the standby module tracks working state of the working module automatically, and will start automatically when it is determined that the working module fails
- Time to switch to servo module: ≤ 10 ms
- Failure determination of working module: The servo module output exceeds the preset maximum and minimum values; the change rate of valve opening direction output by the servo exceeds the preset value



Principle of T800R Redundant Servo:

- Two LVDT stroke feedbacks are connected to the redundant servo modules LVDT respectively
- The working mode of servo module is set to redundant operation
- Servo modules are connected by special redundant wires
- The output end of the servo module is connected in parallel and then connected to the electro-hydraulic converter

Dedicated K-CU03 Fast Master Control System

It meets the following requirements when being applied to ultra-supercritical units

- Rapidity: The fastest calculation cycle is 10 ms and the input-output time is 30 ms, which can meet the rapidity requirements for ultra-supercritical units
- Reliability: It has passed the CE certification of TÜV Rheinland, EMC industrial grade 3A certification and G3 anti-corrosion certification of TÜV Rheinland
- Safety: It adopts 1000 M redundant network, so that all data in the controller can be redundant every cycle to ensure undisturbed switching
- security: It has passed the Achilles Level 2 certification, and can ensure normal communication even in case of network storm.
- High scalability: It supports profibus-DP ModBus-TCP/RTU HART bus protocol

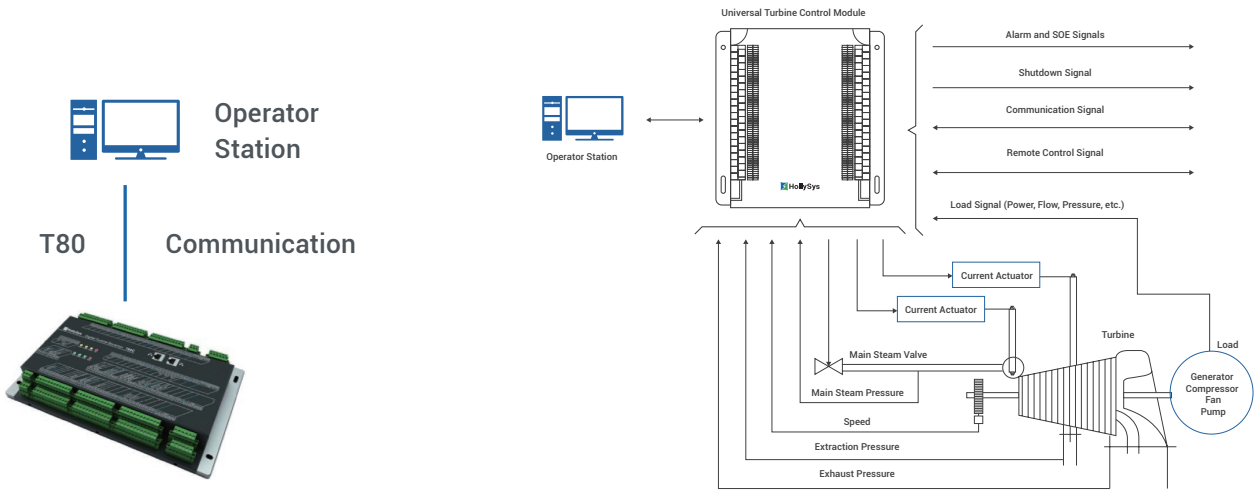
T80/T80C Turbine Control Module Series Products

Overview

The T80/T80C single/dual-channel universal turbine control module is a small turbomachinery control device, which is applicable to various turbine generator sets and industrial driven units of 10 MW and below. The controller hardware is an industrial-grade component which conforms to military standard GJB/Z35-93, and its anti-electromagnetic interference ability conforms to GJB151A, HJB34-1990 and IEC61000-4, so that the controller can operate stably and reliably for a long term in industrial environment.

Characteristics of T80/T80C Products

- With the true full Digital Electro-Hydraulic (DEH) design, it has higher anti-interference capability and self-contained servo power amplifier function, and can drive common electro-hydraulic converters such as DDV valve, VOITH valve and CPC valve directly to cooperate with various hydraulic equipment of OEM
- It is applicable to various units such as waste heat power generation unit, waste power generation unit, biomass power generation unit and solar power generation unit, and provides professional solutions such as isolated grid operation, thermoelectric regulation and sliding pressure operation
- It supports multiple communication modes such as MUDBUS, DP and industrial Ethernet
- The standard series is provided with simple and easy-to-use human-machine interface and an operator station



Schematic Diagram of T80/T80C Control System

Technical Specifications of T80/T80C

- Controller power supply voltage: 24V DC $\pm$ 10%
- Controller current consumption: 2A@24V DC
- Speed input signal: 3 channels, which can receive square wave or sine wave signals
- Servo control signal: 1-2 channels, including 1 for T80 and 2 for T80C
- Analog input signal: 16 channels, 4-20 mA. Channel response time: < 1 ms
- Analog output signal: 6 channels, 4-20 mA. Channel response time: < 1 ms
- DI signal: 24 channels, dry contact input, channel response time of <1 ms
- DO signal: 16 channels, relay output, channel response time of <1 ms
- Communication: 2-channel RS485 communication ports, which support the switching between Modbus RTU and DP protocols
- 2-channel Ethernet interface, which supports Modbus~TCP protocol
- Appearance: L $\times$ W $\times$ H = 360 mm $\times$ 220 mm $\times$ 47.8 mm
- Operating temperature/humidity: -10 $^{\circ}$ C~6 $^{\circ}$ C/5%~95%, non-condensing

Key Control Performance of T80/T80C

- Speed control accuracy: < $\pm$ 1.0r/min
- Load control accuracy: <0.5% Ne (rated load)
- Control cycle: <50ms
- Maximum momentary speed during full load shedding: <7% no (rated speed)
- Extraction pressure control accuracy: $\pm$ 0.5% Pe (rated extraction pressure)
- Mean time between failures (MTBF): >100000h

Main Functions of T80/T80C

- Speed control: unit starting and lifting/lowering speed control, primary frequency regulation function, and isolated grid operation function of turbine unit
- Power control: unit lifting/lowering load and steady load control
- Extraction pressure control: thermoelectric regulation, and operation control by heat/electricity
- Main steam pressure control: For waste heat power station, waste power station and solar thermal power station, closed-loop control of unit main steam pressure can be realized
- Automatic grid connection function: It can be used in conjunction with the automatic quasi-synchronizing device to realize automatic grid connection with initial load
- Coordinated control system (CCS): It can be used in conjunction with DCS system to realize coordinated control of turbine and boiler
- Overspeed protection controller (OPC): It suppresses speed rise to avoid turbine trip in case of load shedding of the unit
- Power, main steam flow and adjustable extraction steam flow limiting functions
- Overspeed protection test (mechanical overspeed protection test, and electrical overspeed protection test functions), valve movement test, valve tightness test, grid connection test, etc
- Simulation test: The T80/T80C controller has the off-line simulation test function

ETS Turbine Emergency Trip System

Overview

Emergency trip system (ETS), also known as turbine protection system, is mainly used to monitor some parameters that have a significant impact on safe operation of the unit. When these parameters exceed the limit value for safe operation, it controls the turbine safety system by operating the trip solenoid valve, closes all steam inlet valves of the turbine, performs emergency shutdown, and provides shutdown diagnosis information for SOE and other systems. The ETS system mainly consists of on-site shutdown action signal detection and acquisition, control logic and control output.



ETS System Products

LM-ETS system:

The HollySys LM series programmable logic controller (PLC) is used to play core functions such as data acquisition, operation and output. The PLC system is used as the main controller, which has advantages such as fast response, high reliability, long service life, centralized management, decentralized control, easy logic modification and increase/decrease of protection conditions.

K-ETS system:

HollySys' fast master control system is used to play core functions such as data acquisition, calculation and output. It has the advantages such as fast response, high reliability, long service life, centralized management, decentralized control, easy logic modification and increase/decrease of protection conditions.

HiaGuard safety class protection system

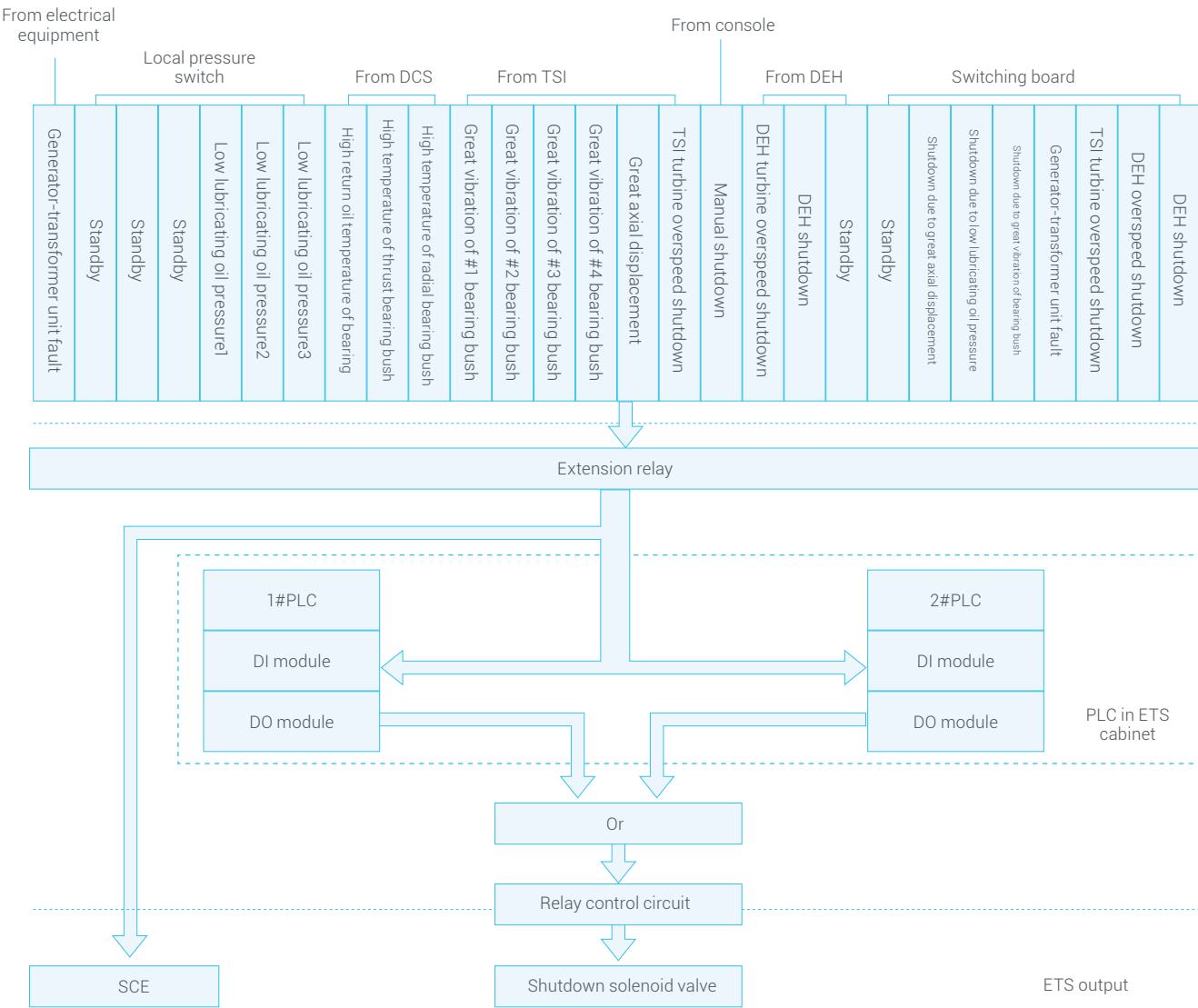
The controller of HiaGuard system is triple-modular, which consists of three independent modules running synchronously. The safety circuit complies with the IEC 61508 SIL3.

LM-ETS System Composition

- The ETS system is usually an independent control cabinet, which is composed of power supply equipment, PLC system, shutdown signal input and expansion, shutdown control signal output and signal indication operation panel
- Power supply equipment: It is used for 220V AC power input and distribution, 24V power conversion and distribution.
- PLC system: Dual redundant PLC is the core control component of ETS system
- Shutdown signal input and expansion: Receive peripheral shutdown signals, distribute them to PLC systems and output them to SOE and DCS systems for use
- Shutdown control signal output: Output the final control signal to the shutdown solenoid valve after judgment and processing by the system, so as to close the automatic main steam valve and shut down the system
- Signal indication operation panel: Indicate the input shutdown signal, power supply and first signal; switching selection and shutdown reset operation

ETS Design Philosophy

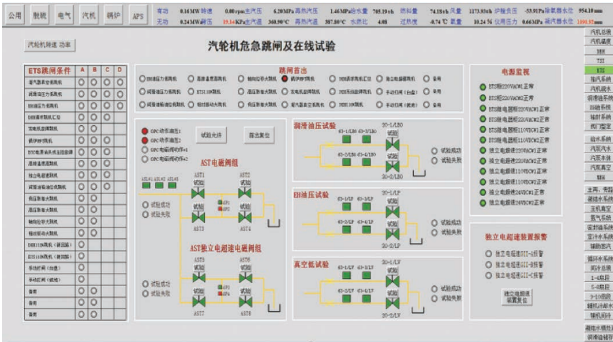
- The ETS system shall be a stand-alone system and an independent controller
- The ETS system must be redundant, so that its normal operation will not be affected, and it still can stop the turbine when any PLC fails
- The ETS system is supplied with independent redundant power, so that it can work normally when any power supply fails. In addition, there is an internal power indicator, which can remotely transmit power indication signal to other systems
- The grounding of ETS system can be connected to the public grounding grid
- The ETS system shall have a communication interface, which can communicate with upper computer or other control systems such as DEH and DCS directly to facilitate data detection. SOE signals can be output through hard wiring to facilitate accident analysis
- Each protection control I/O shall be connected to the ETS system by hard wiring, so as to reduce the intermediate links and delay time of protection control signals and avoid switching, expansion and conversion. The protection control signal shall not be a serial signal, but an independent signal



Schematic Diagram of ETS Protection

Common Protection Conditions of ETS

- Shutdown due to generator-transformer unit fault
- Shutdown due to low lubricating oil pressure
- Shutdown due to great vibration of bearing bush
- Shutdown due to great axial displacement
- TSI turbine overspeed shutdown
- DEH turbine overspeed shutdown
- DEH shutdown
- Shutdown due to high return oil temperature of bearing
- Shutdown due to high temperature of radial bearing bush
- Low condenser vacuum
- MFT action
- Manual shutdown

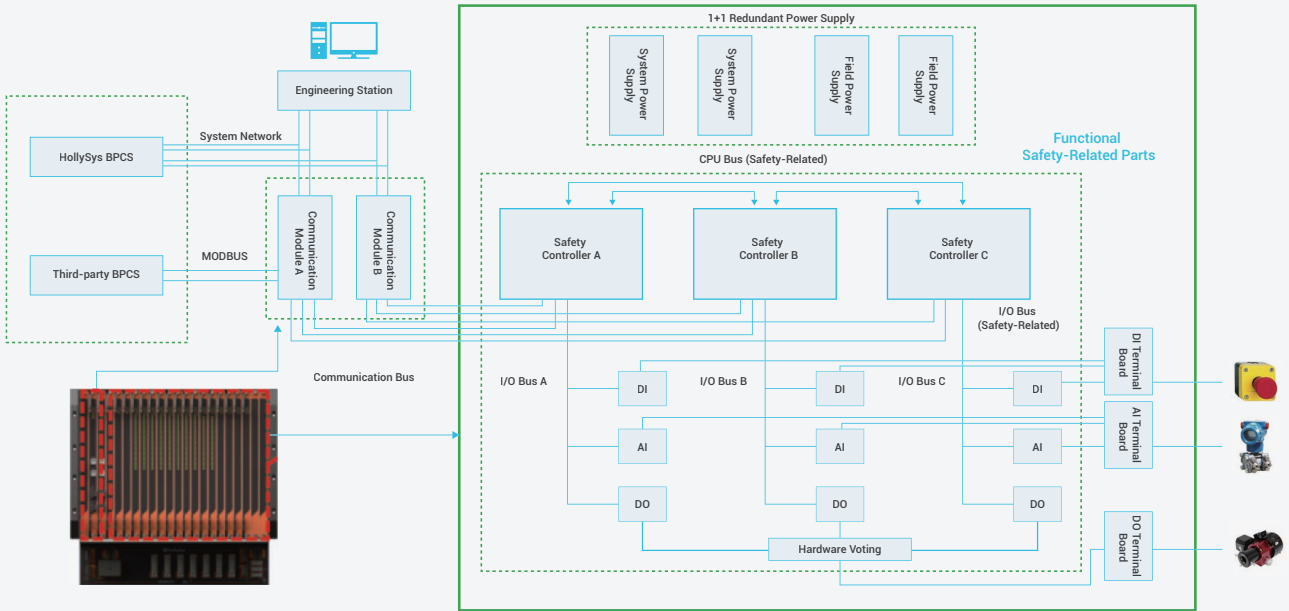


Technical Specifications of ETS Control System

- System control circuit cycle is less than 20 ms
- ETS system MTBF is more than 25,000h
- System availability is not less than 99.9%
- ETS device runs at 0-40° C
- Anti-interference measures are taken for the system to resist the interference from various electromagnetic waves and communication equipment on site.

HiaGuard Safety Class Protection System

The controller of HiaGuard system is triple-modular, which consists of three independent modules running synchronously. I/O channels are triple-modular, which are located in one module physically. I/O modules can be configured separately or redundantly. Safety communication protocol is used to exchange data between triple-modular controllers, and between the controller of each system and the I/O module of this system, so that the safety Loop meets the requirements of IEC 61508 SIL3. Many fault diagnosis measures and proper fault handling measures are taken in the controller and each I/O module of the HiaGuard system through software and hardware. Each module has a diagnostic function with high diagnostic coverage, which minimizes the probability of failure that cannot be diagnosed. Minimizing the probability of multiple faults caused by common causes by reducing the common cause failure design can reduce the maloperation rate effectively.



System Features are as Follows:

- The system continues operating normally even if a single redundant module fails in case of system-level triple redundancy configuration
- The redundant main control unit performs 2oo3 voting on the input data of three I/O channels
- The redundant main control unit runs IECs separately and then sends them to the output module
- The output module performs 2oo3 voting on the calculation results of three main control units and then outputs the results
- The voting Loop delivers final output of the output module after performing the 2oo3 voting
- 2oo3 voting follows a 3-2-0 degradation mode to improve system safety
- Signal input and output delay is less than or equal to 20 ms
- Each subsystem provides data to HMI separately
- HMI communication, IEC operation and IO bus function run on separate CPUs
- SIL3 safety certification of TÜV is passed

Hydraulic Servo System

High-Pressure Fire-resistant Oil Servo System

The high-pressure fire-resistant oil DEH is applicable to the units above 50 MW. The high-pressure fire-resistant oil electro-hydraulic servo system is supplied with oil by a separate high-pressure fire-resistant oil source station. The electro-hydraulic servo-motor is characterized by simple structure, accurate positioning, fast dynamic response and valve management function. However, the working medium used is phosphate ester type high-pressure fire-resistant oil, which is toxic and difficult to degrade in nature, so that environmental pollution will be caused and high costs will be required if a large number of such medium is used. The high-pressure fire-resistant oil servo system is mainly composed of three parts, i.e. high-pressure fire-resistant oil source station, servo actuator and emergency trip device.

High-pressure Fire-resistant Oil Source Station

The high-pressure fire-resistant oil source station is a combined integrated device, which provides qualified high-pressure working oil source to ensure normal operation of the whole hydraulic system. Its working medium is the phosphate ester fire-resistant hydraulic oil with high flame resistance and fluid stability. It is mainly composed of oil tank, oil pump, oil filter, overflow valve, oil cooler, oil heater, accumulator, air filter, air dryer, liquid level indicator, magnetic filter, oil regeneration device and necessary monitoring instruments.



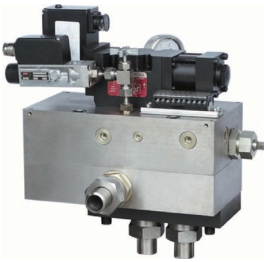
High-pressure Fire-resistant Oil Source Station

Basic Performance of the High-pressure Fire-resistant Oil Source Station:

- Oil source pressure: 14.0MPa
- Working medium: Phosphate ester fire-resistant oil
- Operating temperature of medium: 35-45°C
- Rated flow of (each) pump station: 100L/min (n=1450r/min)
- Motor power of (each) pump station: 30KW 380VAC
- Filtration accuracy of high-pressure filter element: 10 μm (relative filtration accuracy)
- Filtration accuracy of return oil filter element: 3 μm (relative filtration accuracy)

Servo Actuator

The servo actuator consists of two parts, i.e. valve control seat and hydraulic servo-motor, and is driven directly. The hydraulic servo-motor of the servo system compresses spring in the control seat directly to pull up the valve. The opening direction of the valve is consistent with the moving direction of the hydraulic servo-motor, and the valve is closed by the elastic force of the spring in the control seat. The hydraulic servo-motor of high-pressure main steam valve may adopt the two-position switch control mode, or continuous control mode. The high-pressure regulating valve adopts continuous control mode. The continuously controlled hydraulic servo-motor is composed of oil cylinder, displacement sensor, electro-hydraulic converter and control block to realize the valve position closed-loop control system.



Schematic Diagram of Servo Actuator

Product Features

- It is 100% continuously adjustable, and is a closed-loop servo control system
- The dynamic response time is less than 0.3s, and the quick-closing time is less than 0.2s
- The regulation quality fully meets the rapid response requirements under various special working conditions
- The actuator is small in size, easy to install and convenient for on-site maintenance and use
- The actuator has a great output stiffness and can be adjusted online according to the site conditions, regardless of the load type
- With the dual-pump redundant oil supply Loop , intermittent and reliable oil supply control mode with low power consumption and high reliability can be realized
- The fluid working medium is environmentally friendly, and will not cause environmental pollution

Performance Parameters

Item	Parameter
Rated speed	Fully closed-loop stepless speed regulation
Servo valve control signal	±10 V or ±10 mA
Positioning accuracy	Less than 0.1%
Repeatability rate	Less than 0.1%
Response speed	Dynamic response time is less than 20 milliseconds
Quick-closing time	Quick-closing time is 0.2s
Output force range	~35t
Controlled dead band	Less than 0.05% of the full stroke
Type of power supply	380V AC, 24V DC
Power consumption	5KW

EEmergency Trip Device

The emergency trip device is provided with two test pressure switches and four high-pressure trip solenoid valves. In order to realize online test function and trip channel redundancy, the solenoid valve is configured as a series-parallel structure. During normal operation of the unit, the low-pressure turbine safety oil acts on the diaphragm valve of the high-pressure trip module to close the diaphragm valve, close the return oil channel for centralized tripping of high-pressure fire-resistant oil, and supply high-pressure safety oil. If the low-pressure safety oil loses pressure under emergency, the diaphragm valve will open under the action of oil pressure to discharge the high-pressure safety oil, and the unloading valve of each servo-motor will act to trip the unit. Meanwhile, the high-pressure trip solenoid valve can also be actuated by DEH to discharge the high-pressure safety oil and trip the unit.



Schematic Diagram of Servo Actuator

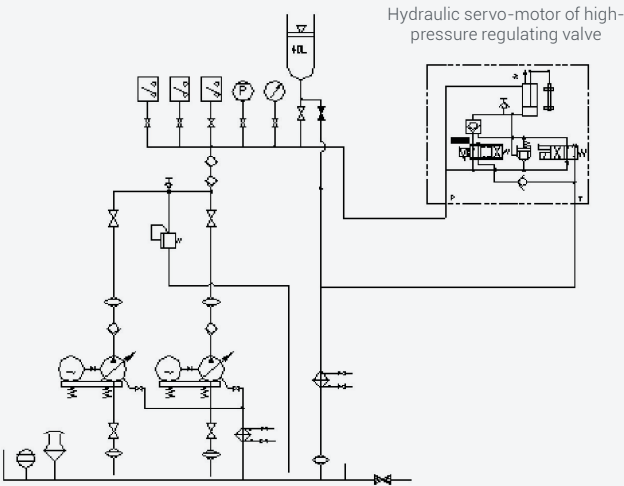
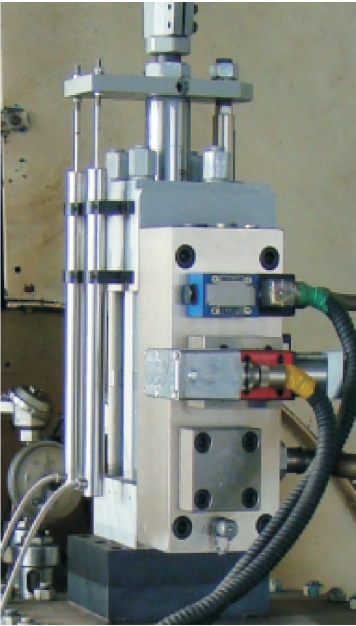
Composition and Principle of Self-Contained Electro-hydraulic Servo System

The self-contained electro-hydraulic servo system is an integral part of the digital electro-hydraulic turbine control system (DEH). It mainly consists of independent oil source devices (oil station, accumulator, antiwear hydraulic oil, etc.), servo actuators (hydraulic servo-motor, servo valve, OPC solenoid directional valve, etc.) and oil pipeline systems (oil pipelines and valves, etc.).

Self-contained Electro-hydraulic Servo System

Overview

The self-contained electro-hydraulic servo system has functions such as high positioning accuracy, great driving force, stepless speed regulation and quick closing protection. It is mainly used for turbomachinery control valve servo-motor and bypass regulating control valve, as well as various ball valves, butterfly valves, control valves, check valves, gate valves, stop valves, instrument valves, sluice valves, pressure relief and safety valves, general valves, sampling valves, electric actuators, pneumatic actuators, hydraulic control systems, positioners and control accessories for industrial applications.



Operating Principle of Servo Actuator

The servo actuator has two main functions, i.e. continuous control of valve opening, and quick closing of valve system, that is, valve quick closing function.

Valve opening control is a typical closed-loop position control system. The DEH electronic device transmits valve position control signal to the servo valve through the servo amplifier, so that the pressure oil port leading to the cylinder is opened, and the high-pressure oil enters lower chamber of the cylinder, making the piston rise and forming a load pressure suitable for the load on the piston end face. The pull rod of the displacement sensor (LVDT) is connected to the piston, therefore, a position signal will be generated by the displacement sensor when the piston moves, and will be fed back to input terminal of the servo amplifier through the demodulator until the piston stops moving when it is balanced with the valve position command. At this time, the steam valve has reached the required opening, completing the conversion among electrical signal, hydraulic pressure and mechanical displacement. When the valve position instruction decreases, the servo valve moves to the other side, the oil port at lower chamber of the cylinder and

connected with the exhaust oil is opened, and the valve closes down under the action of the pressure of the upper chamber until the displacement feedback signal is equal to the instruction signal. In this way, the hydraulic servo-motor adjusts the opening of steam valve continuously with the change of valve position command signal.

The OPC solenoid valve is installed on control block of the hydraulic servo-motor. When the valve works normally, its element separates load pressure from return oil pressure. When emergency shutdown is required, the safety system starts and the safety oil pressure drops to zero. The unloading valve element rises under the action of the oil pressure under the piston of the hydraulic servo-motor, upper and lower cavities of the piston are connected, and oil in the lower cavity flows into the upper cavity in a short time. At this time, the oil pressure under the piston of the hydraulic servo-motor drops rapidly, and the piston of the hydraulic servo-motor closes quickly under high pressure of the upper cavity. When a single hydraulic servo-motor is required for quick-closing test, the OPC solenoid valve shall be electrified.

Independent oil Source Station

The pump station of oil supply unit is driven by two pumps and two motors (one for service and one for standby, which can be switched online), and is mainly composed of accessories such as three-phase AC motor, high-pressure pump, overflow valve, high-pressure filter, check valve, accumulator assembly, return oil filter, water cooler, pressure transmitter, pressure gauge and air filter. If the turbine needs a large flow when being started, or the system pressure is low for some reason, the oil supply device can start the standby pump set automatically through electrical interlocking to meet the system requirements. The structure of oil supply unit ensures online switching repair of pump set when one pump set fails.

The oil supply device is equipped with a pilot-operated overflow valve, which is used as safety valve of the system. When the system pressure is higher than the set value for some reason, the overflow valve will start to protect the system against the impact caused by excessively high pressure. The oil supply device is also provided with several pressure switches, which can give alarms when the system pressure is too low or too high, and start the standby pump set when the system pressure is lower than the set value.



Low-pressure Turbine Oil Servo System

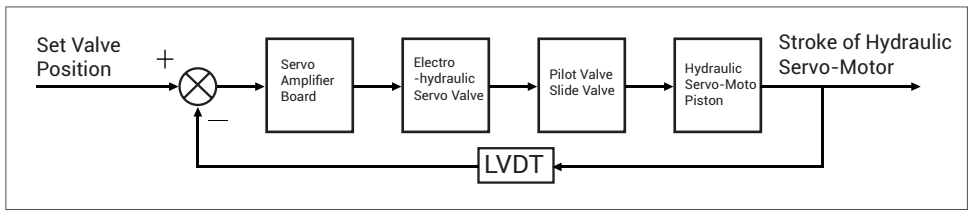
The low-pressure turbine oil servo system is applicable to various small and medium-sized units, and is highly cost effective. The low-pressure turbine oil DEH retains power oil source and safety components of the original hydraulic control system, replaces hydraulic servo-motor of the regulating valve with an electro-hydraulic servo-motor, and controls actions of the regulating valve through the original steam distribution mechanism (cam or lifting plate).

The HollySys low-pressure turbine oil DEH takes a direct drive electro-hydraulic servo valve as the electro-hydraulic conversion device, which improves anti-pollution capability of the low pressure turbine oil control system. The design idea of integrated oil way achieves a standard and integrated control system. The hydraulic spring type servo-motor is designed, which is not affected by changes in system oil pressure, has a high control sensitivity and fast response, provides users with a variety of targeted solutions, and has advantages such as high automation level, economic applicability, high reliability and good environmental protection.

The hydraulic servo-motor valve position command signal generated by the DEH controller passes through the servo amplifier board and DDV valve and transmits a regulating oil pressure to a pilot valve, so as to start the hydraulic servo-motor. The stroke of hydraulic servo-motor is measured by the displacement sensor and fed back to input end of the servo amplifier board to keep it equal to the valve position command of hydraulic servo-motor, so that the stroke is completely controlled by the DEH valve position command.



Hydraulic Integrated Valve Stand for Low-pressure Turbine Oil



Control Block Diagram of Electro-hydraulic Servo-motor

Special Solutions for Different Fields

For units applied to different fields and objects, the HOLLiAS DEH not only has conventional control functions, but also develops special control solutions. The company has designed the following special control solutions and put them into operation:

- DEH solution for intermediate reheat unit
- DEH solution for cogeneration turbine
- DEH solution for waste power station turbine
- DEH solution for biomass power generation turbine
- DEH solution for cement waste heat power station turbine
- DEH solution for combined cycle turbine
- DEH solution for air cooler turbine
- DEH solution for turbines in stand-alone or isolated grid
- Solution for isolated grid stability control system
- DEH solution for the turbine of multi-boiler and multi-machine header operation
- DEH solution for high-pressure fire-resistant oil machine with only one valve
- DEH solution for back pressure fast control turbine in steel mill
- DEH solution for AGC turbine
- Self-contained hydraulic servo-motor system

HollySys Isolated Grid Coordinated System

In case of power imbalance at load side or power generation side of the power grid system due to various reasons, the isolated grid coordinated system can coordinate all kinds of equipment in the power system to make the power grid reach a new electric load balance point in a fast and stable way, thus preventing instability of the power system, failure propagation, and power grid collapse.

The isolated grid coordinated system shall be used as an emergency control device of the power system to coordinate with safety control (automatic frequency and power regulation by DEH, automatic voltage regulation by AVC, etc.) during normal and stable operation, relay protection in case of an accident and recovery control (line reclosing, standby power supply input, automatic startup of standby equipment, etc.) after an accident, so as to ensure safe and stable operation of the power system.

⇒ Neither the Power Grid nor the Isolated Grid Coordinated System Stops!

For the Coordinated and Complete Control Strategy of Isolated Grid, it is Necessary to Know Following Information About the User's Power Grid:

⇒ Traditional Power Grid Load stability Control Mode:

- Perform low-frequency load shedding and high-frequency generator tripping according to the frequency change of power grid system
- Make an accurate mathematical model for user's power grid system under various working conditions, so as to control the load more accurately
- Be applicable to complex large power grid systems

⇒ HollySys Isolated Grid load Stability Control Mode:

- HollySys' isolated grid coordinated system is a collection of control strategies tailored to protect customers' core interests in various enterprise-level power stations, completely isolated grids, short-term grid connection, and short-term isolated grids
- It collects the electric quantity of each bus and heavy load in the user's power system directly, calculates load variation of the power system in real time, performs generator tripping and load shedding under control of the "isolated grid coordinated system" of HollySys fast master control system, and feeds forward the adaptive load variation to the DEH speed control system of the generating set, thus reaching a new load balance point in a fast and stable way
- The isolated grid coordinated system generally sets a 5%-10% dead band for rated electrical load variation of the isolated grid. When electrical load of the isolated grid varies within this range, the isolated grid coordinated system has no output and can transit to a new balance point in a short time only by DEH, DCS, etc
- The HollySys' fast master control (K-CU03) system is used for the collection, calculation and output of electrical loads with an overall delay of about 30-40 ms
- All signals used for calculating electrical load variation are judged by 2oo3 logic
- The regulating system of any one or more grid-connected generator sets, such as diesel generator set, turbine generator set and gas turbine generator set, shall have a qualified primary frequency regulation function, so that it can bear the load change of power grid automatically
- The isolated grid coordinated system is a control system completely independent from conventional DCS, DEH, relay protection system and generator excitation system of the unit. The HollySys K-series fast master control DCS systems are adopted, with a rapid master control operation cycle of 10 ms

- Primary and secondary power circuit diagrams of users.
- Static analysis of various working conditions on power consumption side and generation side of the user's grid, as well as maximum load, minimum load, auxiliary power, etc.
- Prediction and corresponding strategies for various dynamic fluctuations of power load in the user's grid.
- The dead band of isolated grid coordinated fast load reduction control circuit is generally considered to be 5%-10%.
- Analysis of user's thermal load and corresponding strategies.
- Whether there is equipment (such as silicon carbide furnace) with certain electrical load adjustment capability in the user's electric load system.
- Contact mode and control strategy with large power grid.
- Determine whether an independent electric load balance regulation system (water resistance) is required according to dynamic analysis and economic considerations.
- Priority level of power load guarantee for users.
- Setting of electrical protection for power grid main equipment and requirements for frequency.
- Number of user's generator sets, installed capacity, etc.
- Type of turbine generator set: pure condensing, perforated extraction, primary extraction, back pressure, etc.
- Power generation with process waste heat, capacity, etc.
- Boiler type, pulverized coal boiler, fluidized bed boiler, unit system and header system.
- Analysis of user's thermal load and corresponding strategies.
- DEH and DCS system of turbine generator set.
- Type and capacity of turbine bypass system, configuration of temperature and pressure reduction system for heat users, etc.
- Type and capacity of boiler PCV regulating valve.

DEH Install Base

Large and tiny units by 2018
Including new and upgrade units
5116 sets in total

S/N	User	Unit Size	DEH	Turbine Plant
1000 MW unit: (6 sets)				
1	Fujian Shishi Hongshan Thermal Power Plant Phase II of Shenhua Group (bus)	1000MW	DEH	Dongfang Turbine Co., Ltd.
2	Sichuan Shenhua Tianming Power Generation Co., Ltd.	1000MW	DEH	Dongfang Turbine Co., Ltd.
600 MW unit: (30 sets)				
1	Inner Mongolia Guohua Hulunbuir Power Generation Co., Ltd. (air cooling)	600MW	DEH	SAIC
2	Xinjiang Henglian Wucaiwan Power Plant Phase I Project	660MW	DEH	SAIC
3	Datang Pingluo Power Generation Co., Ltd. (bus)	660MW	DEH	SAIC
4	Datang Hunan Zhuzhou Youxian Power Plant	630MW	DEH	Harbin Turbine Company Limited
5	Ningxia Guohua Ningdong Power Generation Co., Ltd. Phase II	660MW	DEH	Harbin Turbine Company Limited
6	Xishangzhuang Thermal Power Project of Yangquan Coal Industry (Group) Co., Ltd.	660MW	DEH	Harbin Turbine Company Limited
7	Hebei Datang Yuxian Power Plant	660MW	DEH	Dongfang Turbine Co., Ltd.
8	Guangdong Shaoguan Yuejiang Power Generation Co., Ltd.	660MW	DEH	Dongfang Turbine Co., Ltd.
9	Guizhou Panxian Power Plant of Guizhou Qiangui Power Generation Co., Ltd.	660MW	DEH	Dongfang Turbine Co., Ltd.
10	Xinjiang East Hope New Energy Co., Ltd.	660MW	DEH	Dongfang Turbine Co., Ltd.

S/N	User	Unit Size	DEH	Turbine Plant
300 MW unit: (220 sets)				
Harbin Turbine Company Limited - 65 sets				
1	Xinjiang Jinhui Zhaofeng Captive Power Station Phase I Project (air cooling)	350MW	DEH	Harbin Turbine Company Limited
2	Heating Center No.2 Factory of Binzhou Beihai New Material Co., Ltd.	330MW	DEH	Harbin Turbine Company Limited
3	Shandong Zouping Changshan Thermal Power Plant	330MW	DEH	Harbin Turbine Company Limited
4	Chongqing Shizhu Power Plant (supercritical)	350MW	DEH	Harbin Turbine Company Limited
5	Datang Binzhou Power Generation Co., Ltd.	350MW	DEH	Harbin Turbine Company Limited
6	Tianshan Aluminum Industry Co., Ltd. Phase II of the Eighth Division of Xinjiang Production and Construction Corps	360MW	DEH	Harbin Turbine Company Limited
7	Huaneng Xining Thermal Power Co., Ltd.	350MW	DEH	Harbin Turbine Company Limited
8	Weiqiao Zhanhua Power Plant Phase II 2X300 MW Unit	300MW	DEH	Harbin Turbine Company Limited
9	Luzhai Power Plant of Guohua Guangxi Investment Group (Liuzhou) Power Generation Co., Ltd.	350MW	DEH	Harbin Turbine Company Limited
10	Huihong New Material Co., Ltd. in Zhanhua District, Bingzhou City	350MW	DEH	Harbin Turbine Company Limited
Dongfang Turbine Co., Ltd. - 64 sets				
1	Fujian Longyan Power Generation Co., Ltd. (CFB)	300MW	DEH	Dongfang Turbine Co., Ltd.
2	Gangue Power Plant of Shenhua Jungar Energy Co., Ltd. (CFB air cooling)	330MW	DEH	Dongfang Turbine Co., Ltd.
3	SPIC Ningxia Linhe Power Station (supercritical)	350MW	DEH	Dongfang Turbine Co., Ltd.
4	Huaneng Linyi Power Generation Co., Ltd.	350MW	DEH	Dongfang Turbine Co., Ltd.
5	Xinjiang East Hope Nonferrous Metals Co., Ltd.	350MW	DEH	Dongfang Turbine Co., Ltd.
6	Haoji Power Plant #3 Unit of Chiping Xinyuan Aluminum Industry Co., Ltd.	360MW	DEH	Dongfang Turbine Co., Ltd.
7	Technical Improvement Phase II Project of Shandong Weiqiao Thermal Power Co., Ltd.	330MW	DEH	Dongfang Turbine Co., Ltd.
8	Sichuan Pangang Group Gangue Captive Power Plant	300MW	DEH	Dongfang Turbine Co., Ltd.
9	Datang 803 Thermal Power Generation Co., Ltd.	330MW	DEH	Dongfang Turbine Co., Ltd.
10	Shaanxi Shenhua Fuping Thermal Power Plant (bus)	350MW	DEH	Dongfang Turbine Co., Ltd.
SAIC - 47 sets				
1	Shaanxi Qingshuichuan Power Generation Co., Ltd. (air cooling)	300MW	DEH	SAIC
2	Gansu SPIC Yongchang Power Generation Co., Ltd. (air cooling)	300MW	DEH	SAIC
3	Huaneng Shandong Baiyanghe Power Plant	300MW	DEH	SAIC
4	Inner Mongolia Jingke Power Co., Ltd. (air cooling)	330MW	DEH	SAIC
5	Shenhua Xinjiang Midong Thermal Power Plant (CFB air cooling)	300MW	DEH	SAIC
6	Ningxia Qingtongxia Aluminum Industry Captive Power Plant	330MW	DEH	SAIC
7	Datang Linzhou Thermal Power Plant (supercritical)	350MW	DEH	SAIC
8	Tumxuk Thermal Power Plant of the Third Division of Xinjiang Production and Construction Corps (supercritical)	350MW	DEH	SAIC
9	Inner Mongolia Jingneng Jining Thermal Power Generation Co. Ltd.	350MW	DEH	SAIC

S/N	User	Unit Size	DEH	Turbine Plant
Nanjing Turbine & Electric Machinery (Group) Co., Ltd. - 32 sets				
1	Shandong Nanshan Group Aluminum Industry Captive Power Plant	330MW	DEH	Nanjing Turbine & Electric Machinery (Group) Co., Ltd.
2	Shandong Binteng Textile Co., Ltd. Thermal Power Plant	330MW	DEH	Nanjing Turbine & Electric Machinery (Group) Co., Ltd.
3	Shandong Zouping Changshan Thermal Power Plant	330MW	DEH	Nanjing Turbine & Electric Machinery (Group) Co., Ltd.
4	Shandong Weiqiao No.1 Power Plant	330MW	DEH	Nanjing Turbine & Electric Machinery (Group) Co., Ltd.
5	Shandong Huimin New Material Co., Ltd. Thermal Power Plant	330MW	DEH	Nanjing Turbine & Electric Machinery (Group) Co., Ltd.
6	Yangxin Binbei New Material Co., Ltd.	330MW	DEH	Nanjing Turbine & Electric Machinery (Group) Co., Ltd.
7	Linhe Power Generation Branch of SPIC Ningxia Energy Aluminum Industry Co., Ltd.	300MW	DEH	Nanjing Turbine & Electric Machinery (Group) Co., Ltd.
8	Huimin Huji Power Plant Phase II 4X300 MW Unit	300MW	DEH	Nanjing Turbine & Electric Machinery (Group) Co., Ltd.
NHI - 12 sets				
1	Coal Power Co., Ltd. of the Sixth Division of Xinjiang Production and Construction Corps	360MW	DEH	NHI
2	Haoji Power Plant of Chiping Xinyuan Aluminum Industry Co., Ltd.	360MW	DEH	NHI
3	Xinjiang Qiya Aluminum and Electricity Co., Ltd.	360MW	DEH	NHI
4	Datang Yan' an Power Plant (bus)	350MW	DEH	NHI
200 MW~150 MW units: (60 sets)				
1	Maoxi Power Plant in Vietnam	N220MW	DEH	Dongfang Turbine Co., Ltd. 20 sets
2	Guizhou Qingzhen Power Plant	N200MW	DEH	
3	Zhengzhou Rongqi Thermal Power Energy Co., Ltd.	N210MW	DEH	Harbin Turbine Company Limited 20 sets
4	Shijingshan Thermal Power Plant	C200MW	DEH	
5	Guangxi Liuzhou Power Plant	N200MW	DEH	NHI 10 sets
6	Shanxi Guanlv Yuncheng Thermal Power Plant	N210MW	DEH	
7	Shandong Chiping Xinfu Hope Aluminum Industry Co., Ltd.	C155MW	DEH	Wuhan Turbine 10 sets
8	Henan Yima Thermal Power Plant	C155MW	DEH	
150 MW~3 MW units: (4400 sets)				
1	Henan Luoyang Thermal Power Plant	N75MW	DEH	Dongfang Turbine Co., Ltd. 100 sets
2	United Laboratories (Inner Mongolia) Co., Ltd.	C60MW	DEH	
3	Taicang Port Environmental Protection Power Generation Co., Ltd. in Taicang City, Jiangsu	C135MW	DEH	SAIC 100 sets
4	Sinopec Yizheng Chemical Fibre Co., Ltd. Thermal Power Plant	C60MW	DEH	
5	Thermal Power Plant of Jilin Petroleum Group Co., Ltd.	B50MW	DEH	Harbin Turbine Company Limited 110 sets
6	SINOBO Outer Mongolia Molybdenum Ore Captive Power Plant	3XC7.5MW	DEH	

S/N	User	Unit Size	DEH	Turbine Plant
7	Shanxi Liulin Power Plant N100 MW	C155MW	DEH	NHI 110 sets
8	Guangxi Heshan Power Plant	N75MW	DEH	
9	Yunnan Xiangyun Feilong Co., Ltd.	C50MW	DEH	Wuhan Turbine 1100 sets
10	Pingshan Jingye Group Co., Ltd.	N50MW	DEH	
11	Hengxian Guangui Sugar Industry Co., Ltd.	CC12MW	DEH	Qingdao Automobile 1200 sets
12	Yunnan Luxi Dawei Coking Co., Ltd.	C12MW	DEH	
13	Fujian Southeast Electrochemical Co., Ltd.	CC15MW	DEH	Hangzhou Turbine & Power 200 sets
14	Shandong Dongying Hengyang Chemical Co., Ltd.	B12MW	DEH	
15	Sinopec Jiujiang Petrochemical Company	CC50MW	DEH	Nanzhong 300 sets
16	Zhejiang Sanxing Thermal Power Co., Ltd.	B50MW	DEH	
17	Liyang Changxing Steel Supporting Facilities Co., Ltd. Project of Beijing Xinli Zhuzheng New Energy Technology Co., Ltd.	N20MW	DEH	Luofa 190 sets
18	Jinzhou Waste Heat Power Plant	N3MW	DEH	
19	Xiangyang Zedong Chemical Group Co., Ltd.	1XC3	DEH	Qingneng 110 sets
20	Shandong Yujia New Material Co., Ltd.	N3MW	DEH	
21	Others		DEH	350 sets
100 MW high-temperature and high-pressure intermediate reheat unit: (30 sets)				
1	Tangshan Donghai Steel Group Special Steel Co., Ltd.	80MW	DEH	Dongfang Turbine Co., Ltd. 25 sets
2	Guangxi Shenglong Metallurgical Co., Ltd.	80MW	DEH	
Industrial driven turbine unit: (~150 sets)				
1	Guohua Taishan Power Plant in Guangdong	Feed pump	MEH	Hangzhou Turbine & Power
2	Jiangsu Huaiyin Power Generation Co., Ltd.	Feed pump	MEH	Harbin Turbine Company Limited
3	Baqiao Power Plant	Feed pump	MEH	Liangxiang
4	Fujian Longyan Kengkou Thermal Power Plant Phase II	Feed pump	MEH	Dongfang Turbine Co., Ltd.
5	Huaneng Jining Power Plant	Feed pump	MEH	Qingdao Automobile
6	Guangxi Shenglong Metallurgical Co., Ltd.	Blower	MEH	Hangzhou Turbine & Power
7	Jiangsu Suyan Jingshen Co., Ltd.	Circulating water pump	MEH	Hangzhou Turbine & Power
8	Inner Mongolia Jingneng Kangbashi Thermal Power Co., Ltd.	Draught fan	MEH	Hangzhou Turbine & Power
9	Jiuquan Iron & Steel (Group) Co., Ltd.	Blower	MEH	Soviet Union
10	No. 703 Research Institute of CSIC	Marine power	MEH	703
11	Hebei Shenghua Chemical Engineering Co., Ltd.	Chemical pump	MEH	Xianghuaji